NATURAL RESOURCES CONSERVATION SERVICE
CONSERVATION PRACTICE STANDARD

POND
(No.)
CODE 378

DEFINITION

A water impoundment made by constructing an embankment or by excavating a pit or dugout.

In this standard, ponds constructed by the first method are referred to as embankment ponds, and those constructed by the second method are referred to as excavated ponds. Ponds constructed by both the excavation and the embankment methods are classified as embankment ponds if the depth of water impounded against the embankment at the auxiliary spillway elevation is 3 feet or more.

PURPOSE

To provide water for livestock, fish and wildlife, recreation, fire control, and other related uses, and to maintain or improve water quality.

Water impoundments that have the primary purpose to stabilize grade and control erosion shall meet the requirements of conservation practice standard Grade Stabilization Structure (410).

CONDITIONS WHERE PRACTICE APPLIES

This standard establishes the minimum acceptable quality for the design and construction of low-hazard ponds where:

1. Failure of the dam will not result in loss of life; in damage to homes, commercial or industrial buildings, main highways, railroads; or in interruption of the use of public utilities.
2. The product of the storage times the effective fill height of the dam is less than 3,000 acre-feet[2]. Storage is the volume (acre-feet), in the reservoir below the elevation of the crest of the auxiliary spillway. The effective fill height of the dam is the difference in elevation (feet) between the auxiliary spillway crest and the lowest point in the cross section along the centerline of the dam. For dams on existing roads or other sites without a measurable channel at centerline, the lowest elevation at the downstream toe will be used to determine effective height. If there is no auxiliary spillway, the lowest elevation along settled top of dam is the upper limit.
3. The overall height of the dam is less than 35 feet, and the dam is hazard class (a). Refer to National Engineering Manual Part 520.20 for definitions of dam classes.

Overall height is the difference in elevation in feet between the lowest elevation in the top of dam (excluding the auxiliary spillway) and the lowest elevation in the natural bed of the stream or watercourse or the lowest point on the toe of the dam (whichever is lower).

Dams with an overall height of 35 feet or more shall meet the requirements of the Missouri Department of Natural Resources, Dam and Reservoir Safety Council and meet or exceed the requirements of Technical Release 60 (TR-60).

Any dam beyond the scope of this standard will be designed in accordance with Technical Release 60 (TR-60). See Section 520.22, National Engineering Manual for definition of classes of dams.

CRITERIA

General Criteria Applicable To All Ponds

All federal, State and local requirements shall be addressed in the design.

Site Conditions. Site conditions shall be such that runoff from the design storm (see Table 3) can safely pass through (1) a natural or constructed auxiliary spillway, (2) a

combination of a principal spillway and an auxiliary spillway, or (3) a principal spillway.

Drainage Area. The drainage area above the pond must be protected against erosion to the extent that expected sedimentation will not shorten the planned effective life of the structure. The drainage area shall be large enough so that surface runoff and subsurface flow will maintain an adequate supply of water in the pond for the intended purpose(s). The water quality shall be suitable for its intended use. Missouri supplement to the National Engineering Handbook (NEH) Part 650, Engineering Field Handbook (EFH) Chapter 11, may be used as a guide in determining minimum size of contributing drainage area.

Reservoir Area. The topography and soils of the site shall permit storage of water at a depth and volume that insures a dependable supply, considering beneficial use, sedimentation, season of use, and evaporation and seepage losses. If surface runoff is the primary source of water for a pond, the soils shall be impervious enough to prevent excessive seepage losses or shall be of a type that sealing is practicable.

The minimum pond size shall be that required to meet the calculated needs. The minimum depth shall be 8 feet over 10 percent of the normal water surface area unless fish production is an important design consideration. Where underlying material prevents excavation to 8 feet, the minimum depth shall be 5 feet over 25 percent of the normal water surface. Minimum depth and surface area does not apply to ponds primarily for wildlife water.

Ponds Primarily for Fish Production. For best management, minimum surface area should be 1.0 acre. Ponds shall be at least eight (8) feet deep over an area of approximately 1,000 square feet. Shoreline, excluding embankment and waterway outlets into the pond, shall be sloped 3 (horizontal) to 1 (vertical) or steeper from normal water surface to a depth of 3 feet. On ponds with a surface area of 6 acres or greater, this requirement may be reduced to 75 percent of the shore line. For ponds larger than 3 acres, provisions shall be made to drain the pond in a 14-day period. An available pumping system of adequate size will meet this requirement.

Management shall be according to conservation practice standard Fishpond Management (399).

Geological Investigations. Sufficient investigations shall be made of the pond site, embankment foundation, auxiliary spillway and borrow areas to determine suitability of site and materials for construction, dam stability, and water holding ability. A complete analysis of foundation and earth fill materials shall be made when, in the opinion of the responsible engineer, such an analysis is necessary. National Engineering Manual - Part 531 and Missouri supplements regarding dam site investigations will be followed. Soil materials shall be classified using the Unified Soil Classification System.

Cultural Resources. Consider existence of cultural resources in the project area and any project impacts on such resources. Consider conservation and stabilization of archeological, historic, structural, and traditional cultural properties when appropriate.

Fence. Where an adjacent area is used for grazing or is open to livestock, the pool area, earthfill, and vegetative spillway shall be fenced to exclude livestock. Where watering ramps are constructed in an excavated pond, the fence shall permit livestock access to the ramp area only. In other cases the fence will be located no closer than 25 feet (horizontal distance) from the normal water line. Fence materials and fence installation shall be as outlined in the standards and specifications for conservation practice standard Fence (382).

Where the pond is to be developed as wildlife land, the fence will be located no closer than 40 feet to the sides of the normal water and 70 feet from the upper end of the normal pool.

Fencing may be necessary to exclude traffic that may endanger the vegetative cover on the embankment and spillway areas and to prevent the use of the facilities for purposes other than intended.

Vegetation. The exposed surfaces of the embankment, earth spillway, borrow areas, and other areas disturbed during construction shall be seeded or sodded. The seedbed preparation and treatment and the seeding mixtures and methods shall be as outlined in

the standards and specification for conservation practice standard Critical Area Planting (342).

National Inventory. The following dams are to be included in the National Inventory of NRCS assisted dams in accordance with National Engineering Manual Part 520.21(f):

1. All hazard class (b) and (c) dams;
2. Class (a) dams more than 6 feet in overall height and with a storage capacity of 50 acre-feet or more; or
3. Class (a) dams with an overall height of 25 feet or more and a storage capacity of more than 15 acre-feet.

Inventory dams shall be reported to the State Conservation Engineer using form MO-ENG-C94.

Design Criteria for Embankment Ponds

Foundation Cutoff. A cutoff of relatively impervious material shall be provided under the dam if necessary to reduce seepage through the foundation. The cutoff shall be located at or upstream from the centerline of the dam. It shall extend up the abutments as required and be deep enough to extend into a relatively impervious layer or provide for a stable dam when combined with seepage control. The cutoff trench shall have a bottom width adequate to accommodate the equipment used for excavation, backfill, and compaction operations. Side slopes shall be 1-1/2 (horizontal) to 1 (vertical) or flatter as needed to be stable. The cutoff shall be of sufficient size and extent to prevent excessive seepage under or around the dam.

Seepage Control. Seepage control is to be included if (1) pervious layers are not intercepted by the cutoff, (2) seepage could create swamping downstream, (3) such control is needed to insure a stable embankment, or (4) special problems require drainage for a stable dam. Seepage may be controlled by (1) foundation, abutment, or embankment filters and drains; (2) reservoir blanketing; or (3) a combination of these measures.

Earth embankment. The minimum top width for a dam is shown in the following table. If the embankment top is to be used as a public road, the minimum width shall be 16 feet for one-way traffic and 26 feet for two-way traffic. When embankment top is to be used as a farm road, the minimum top width is 12 feet. Guardrails or other safety measures shall be used where necessary and shall meet the requirements of the responsible road authority. For dams less than 20 feet in height, maintenance considerations or construction equipment limitations may require increased top widths from the minimum shown in the table.

Minimum Dam Top Width

Total height of embankment (feet)	**Top width** (feet)
Less than 10	6
10 – 14.9	8
15 – 19.9	10
20 – 24.9	12
25 – 34.9	14

Side Slopes. The combined upstream and downstream side slopes of the settled embankment shall not be less than 6 (horizontal) to 1 (vertical), and no slope steeper than 2-1/2 (horizontal) to 1 (vertical). All slopes must be designed to be stable, even if flatter slopes are required. Slope stability shall be evaluated based on soil mechanics analysis or past experience in the surrounding area. Downstream or upstream berms can be used to help achieve stable embankment sections.

Slope Protection. Suitable vegetation shall be established on all earth dams and adjacent critical areas.

If needed to protect the slopes of the dam from erosion, special measures, such as berms, rock riprap, sand-gravel, soil cement, or special vegetation, shall be provided (Technical Release 56 (TR-56), “A guide for Design and Layout of Vegetative Wave Protection for Earth Dam Embankments”, Technical Release 69 (TR-69), “Riprap for Slope Protection Against Wave Action” and the Missouri supplement to TR-69 “Estimating the Need for Slope Protection for Dams” contain design guidance).

Potential wave erosion factors such as orientation, exposure, and fetch length should be considered for all ponds to determine if protection is needed. History of other sites in surrounding area shall be considered when

evaluating wave protection. In some areas wave erosion is severe even on small pool areas.

Wave erosion protection shall be provided on the dam for all reservoirs exceeding 5 acres surface area unless otherwise evaluated and approved by the responsible engineer. Minimum wave protection to be used: (1) an 8 foot berm at principal spillway elevation or (2) construct upstream slope 4 (horizontal) to 1 (vertical) or flatter. For pool sizes of 10 acres or more, compute wave height by Technical Release - 56 (TR-56) or Technical Release 69 (TR-69). Wave heights over 1 foot may require sloping berms or rock riprap.

Freeboard. The minimum elevation of the top of the settled embankment shall be 1 foot above the water surface in the reservoir with the auxiliary spillway flowing at design depth. The minimum difference in elevation between the crest of the auxiliary spillway and the settled top of dam shall be 2 feet for all dams having more than a 20-acre drainage area or more than 20 feet in effective height.

Settlement. The design height of the dam shall be increased by the amount needed to insure that after settlement the height of the dam equals or exceeds the design height. The actual percent increase selected by designer shall be based on (1) soil mechanics test results, (2) history of dams in the surrounding area, and (3) the type of compaction designated. The following minimum shall be met:

(a) 3 to 5 percent increase where fill material is placed in 9-inch layers and compacted by heavy hauling equipment or liquid filled tamping roller. (Sheepsfoot or wedgefoot drum rollers are considered tamping rollers.)

(b) 5 to 10 percent increase where fill construction and compaction is by bulldozer or light hauling equipment, i.e., unloaded scrapers. Individual layers shall be 5 inches in thickness or less.

Principal Spillway. A pipe conduit, with needed appurtenances, shall be placed under or through the dam except where rock, concrete or other types of mechanical spillways are used or where the rate and duration of flow can be safely handled by a vegetated or earth spillway.

For dams with a drainage area of 20 acres or less, the principal spillway crest elevation shall not be less than 0.5 feet below the auxiliary spillway crest elevation. For dams with a drainage area over 20 acres, this difference shall not be less than 1.0 feet.

When design discharge of the principal spillway is considered in calculating peak outflow through the auxiliary spillway, the crest elevation of the inlet shall be such that full flow will be generated in the conduit before there is discharge through the auxiliary spillway. Sufficient stage (difference in elevation between crest of auxiliary spillway and invert of principal spillway inlet) shall be provided to insure efficient use of principal spillway. The inlet section and outlet section shall be designed to function satisfactorily for the full range of flow and hydraulic head anticipated.

The capacity of the pipe conduit shall be adequate to discharge long duration, continuous, or frequent flows without flow through the auxiliary spillway. The diameter of the pipe shall not be less than 4 inches. If the pipe conduit is 10 inches or greater, its design discharge may be considered in the hydraulic design.

Table 3 gives the minimum requirements for sizing the principal spillway and determining the temporary water storage volume needed in determining the stage required between the crest of the principal spillway and the flow line of the auxiliary spillway.

Pipe conduits under or through the dam shall meet the following requirements: (1) the pipe shall be capable of withstanding external loading without yielding, buckling, or cracking, (2) pipe strength shall not be less than that of the grades indicated in Table 1 or Table 1a for PVC plastic pipe and in Table 2 for corrugated aluminum and galvanized corrugated steel pipe, (3) the inlet and outlet sections shall be structurally sound and made of materials compatible with that of the pipe, and (4) all pipe joints shall be made watertight by the use of couplings or gaskets or by welding or caulking.

The conduit slope shall be adequate to provide positive drainage after consolidation has occurred. Slope of the outlet section for

conduits 15 inches in diameter or greater shall not exceed 7 percent.

When conduit design requires an elbow, the outlet section from the elbow to outlet end shall not be less than 16 feet in length. The conduit extension beyond end support or downstream toe of fill shall not be less than 6 feet.

Invert of the outlet pipe section shall be no higher than 2 feet above the outlet channel flowline unless otherwise approved by the responsible engineer.

Acceptable pipe materials for total fill heights are:

(a) 35 feet or less

- Cast in place reinforced concrete
- Reinforced concrete pipe
- Ductile iron pipe
- New or good quality used welded steel pipe
- Corrugated steel pipe
- Corrugated aluminum pipe

(b) 20 feet or less

- Cast in place reinforced concrete
- Reinforced concrete pipe
- Ductile iron pipe
- New or good quality used welded steel pipe
- Corrugated steel pipe
- Corrugated aluminum pipe
- Plastic pipe (as listed in Tables 1 and 1a)

Welded steel pipe shall meet tolerance requirements of ASTM A53 or equivalent specifications. Welded steel pipe shall be new, new reject, or high quality used pipe.

Minimum effective* wall thickness for welded steel pipe shall be:

(a) 3/16 (0.1875) inches for pipe diameters 24 inches or less

(b) 1/4 (0.25) inches for pipe diameters over 24 inches

* effective wall thickness - wall thickness minus maximum depth of rust or corrosion pits

Aluminum pipe will not be used in soils that are outside the pH range of 4 to 9.

Concrete pipe shall be laid in a concrete bedding or a concrete cradle, if required.

Plastic pipe that will be exposed to direct sunlight shall be made of ultraviolet-resistant materials and protected by coating, shielding, or provisions for replacement as necessary. Connections of plastic pipe to less flexible pipe or structures must be designed to avoid stress concentrations that could rupture the plastic pipe.

The maximum height of fill over any pipe must be evaluated by Technical Release 77 (TR-77), using Tables 1, 1a, 2, or other suitable methods. Pipe shall be watertight. The joints between sections of pipe shall be designed to remain watertight after joint elongation caused by foundation consolidation.

Cantilever outlet sections, if used, shall be designed to withstand the cantilever load. Pipe supports shall be provided when needed. Outlet pipe supports will be used on conduits larger than 18 inches for corrugated metal pipe and larger than 24 inches for welded steel pipe. For all pipe sizes, PVC plastic pipe shall not protrude from the embankment more than six (6) feet unless an outlet pipe support is installed. Pipe support will be according to an approved standard design and will be installed at the intersection of downstream slope of fill and outlet channel. Other suitable devices such as a Saint Anthony Falls (SAF) outlet or impact basin may be used to provide a safe outlet.

Cathodic Protection. Cathodic protection shall be provided to reduce corrosion of welded steel and corrugated steel pipe if the need and importance of the structure warrant. Cathodic protection should normally be provided for corrugated steel pipe if the saturated soil resistivity is less than 4,000 ohms-cm or the pH is lower than 5. Conservation Practice Standard Irrigation Water Conveyance, Steel Pipeline (430-FF) provides criteria for cathodic protection of welded steel pipe. A pipe layout that ensures good drainage reduces the rate of metal corrosion. In highly corrosive soils use of alternate pipe materials such as plastic pipe should be considered.

Anti-seep Collars. Anti-seep collars shall be installed around the pipe conduit or pond drain pipe in the normal saturation zone if any of the following conditions exist:

1. The overall height of the dam exceeds 15 feet.
2. The conduit is smooth pipe larger than 8 inches in diameter.
3. The conduit is corrugated metal pipe larger than 12 inches in diameter.

Anti-seep collars and their connections to the pipe shall be watertight. The collar material shall be compatible with pipe materials. The maximum spacing shall be approximately 14 times the minimum projection of the collar measured perpendicular to the pipe but shall not exceed 25 feet. Minimum collar spacing is 10 feet. Minimum collar projection is 1.0 foot. For design considerations, see Missouri supplement to Chapter 6 of the National Engineering Handbook (NEH) Part 650, Engineering Field Handbook.

Closed conduit spillways designed for pressure flow must have adequate antivortex devices.

If needed to prevent clogging of the conduit, an appropriate trash guard shall be installed at the inlet or riser entrance. For safety reason, all vertical drop inlets will be constructed to prevent accidental injury to livestock and humans. This may be accomplished by using a horizontal antivortex baffle, trash rack, or guard rail.

Other Pipelines. A pipe with a suitable valve shall be provided to drain the pool area if needed for proper pond management or if required by state law. The principal spillway conduit may be used as a pond drain if it is located so as to accomplish this function.

Supply pipe through the dam to watering troughs and other appurtenances shall have an inside diameter of not less than 1-1/4 inches Supply pipes shall be installed in conjunction with a suitable intake device with strainer, valve, and provisions to avoid freezing.

When tanks or troughs are planned in conjunction with the supply pipe, the requirements of conservation practice standard Water Facility (614) shall be met.

Dry hydrant installations may be planned with new pond construction. Dry hydrants through embankments shall be installed in accordance with principal spillway criteria.

Trickle tube capacity shall be at least equal to the maximum spring or base flow. Minimum tube size is 4 inch diameter. Crest elevation shall be at least 0.5 foot below the crest of the auxiliary spillway. Trickle tubes through the dam shall meet all requirements for a principal spillway except flood-routing is not required. Trickle tubes installed in the abutment around the end of the dam may be corrugated polyethylene or polyvinyl chloride tubing. Tubing may be installed through the dam at a point where the height of dam above natural ground is 3 feet or less and a minimum of 9 inches of sand backfill is placed all around the conduit, beneath the top width of the dam. Pipes or tubing with equivalent strength and durability may be used.

Auxiliary Spillways. Auxiliary spillways convey large flows safely downstream from earth embankments.

An auxiliary spillway must be provided for each dam, unless the principal spillway is large enough to pass the routed design hydrograph peak discharge and the trash that comes to it without overtopping the dam. A closed conduit principal spillway having a conduit with a cross sectional area of 3 sq ft or more, an inlet that will not clog, and an elbow designed to facilitate the passage of trash is the minimum size and design that may be used without an auxiliary spillway. The minimum capacity of a natural or constructed auxiliary spillway shall be that required to pass the peak flow from a design storm of the frequency and duration shown in Table 3 less any reduction creditable to conduit discharge and detention storage.

The auxiliary spillway shall safely pass the peak flow or the storm runoff shall be routed through the reservoir. The routing shall start with the water surface at the elevation of the crest of the principal spillway or at the water surface after 10 days drawdown, whichever is higher. The 10-day drawdown shall be computed from the crest of the auxiliary spillway or from the elevation that would be attained if the entire design storm were impounded, whichever is lower. Auxiliary spillways shall provide for passage of the design flow at a safe velocity to a point

downstream where the dam will not be endangered.

Constructed auxiliary spillways are open channels and usually consist of an inlet channel, a control section, and an exit channel. They shall be trapezoidal and shall be located in undisturbed or compacted earth. The side slopes shall be stable for the material in which the spillway is to be constructed. Spillway side slopes shall be 2-1/2 (horizontal) to 1 (vertical) or flatter. Auxiliary spillway shall have a bottom width of not less than 10 feet

Upstream from the control section, the inlet channel shall be level upstream for at least 25 feet or a distance needed to protect and maintain the crest elevation of the spillway. The inlet channel may be curved to fit existing topography. The grade of the exit channel of a constructed spillway shall fall within the range established by discharge requirements and permissible velocities.

Spillway dikes or shaped exit channels shall extend to the point downstream that ensures the spillway flows do not damage the earth embankment. Side slopes of the constructed spillway dike shall have a slope of 2-1/2 (horizontal) to 1 (vertical) or flatter, a minimum top width of 4 feet, and a minimum height of 2 feet above the spillway grade.

Structural Auxiliary Spillways. If chutes or drop spillways are used for principal spillways or auxiliary spillways, they shall be designed according to the principles set forth in the National Engineering Handbook (NEH) Part 650, Engineering Field Handbook for Conservation Practices; National Engineering Handbook, Section 5, Hydraulics, Section 11, Drop Spillways, and Section 14, Chute Spillways. The minimum capacity of a structural spillway shall be that required to pass the peak flow expected from a design storm of the frequency and duration shown in Table 3 less any reduction creditable to conduit discharge and detention storage.

Design Criteria for Excavated Ponds

Runoff. Provisions shall be made for a pipe and auxiliary spillway if necessary. Runoff flow patterns shall be considered when locating the pit and placing spoil material (see Table 3).

Side slopes. Side slopes of excavated ponds shall be stable and shall not be steeper than 2-1/2 (horizontal) to 1 (vertical). If livestock will water directly from the pond, a watering ramp of ample width shall be provided. The ramp shall extend to the anticipated low water elevation at a slope no steeper than 4 (horizontal) to 1 (vertical).

Perimeter Form. If the structures are to be used for recreation or are located in high public view, the perimeter or edge must be curvilinear in form.

Inlet Protection. If surface water enters the pond in a natural or excavated channel, the side slope of the pond shall be protected against erosion.

Excavated Material. The material excavated from the pond shall be placed so its weight will not endanger the stability of the pond side slopes and where it will not be washed back into the pond by rainfall. It shall be disposed of in one of the following ways:

1. Uniformly spread to a height not exceeding 3 feet with the top graded to a continuous slope away from the pond.
2. Uniformly placed or shaped reasonably well with side slopes assuming a natural angle of repose for the excavated material behind a berm width equal to the depth of the pond but not less than 12 feet
3. Shaped to a designed form that blends visually with the landscape.
4. Used for low embankment and leveling.
5. Hauled away.

CONSIDERATIONS

Visual Resource Design. The visual design of ponds should be carefully considered in areas of high public visibility and those associated with recreation. The underlying criterion for all visual design is appropriateness. The shape and form of ponds, excavated material, and plantings are to relate visually to their surroundings and to their function.

The embankment may be shaped to blend with the natural topography. The edge of the pond may be shaped so that it is generally curvilinear rather than rectangular. Excavated

material can be shaped so that the final form is smooth, flowing, and fitting to the adjacent landscape rather than angular geometric mounds. If feasible, islands may be added for visual interest and to attract wildlife.

Safety. Since ponds are potentially hazardous, safety aspects must be considered in the design. If the area is used for recreation, it is recommended to erect warning signs, place lifesaving equipment nearby, and post instructions of what to do in emergencies.

Fish and Wildlife. Project location and construction should minimize the impacts to existing fish and wildlife habitat.

Where more than one site location exists, final location that disturbs the least amount of wildlife habitat should be selected. Consider landowner's priorities and select the site that best achieves the objectives with the least negative impact on other important resources.

When feasible, structure should be retained, such as trees in the upper reaches of the pond and stumps in the pool area. Upper reaches of the pond can be shaped to provide shallow areas and wetland habitat.

Vegetation. Stockpiling topsoil for placement on disturbed areas can facilitate revegetation.

Consider placement and selection of vegetation to improve fish and wildlife habitat and species diversity.

Water Quantity. Consider effects upon components of the water budget, especially:

- Effects on volumes and rates of runoff, infiltration, evaporation, transpiration, deep percolation, and ground water recharge.
- Variability of effects caused by seasonal or climatic changes.
- Effects on downstream flows and impacts to environment such as wetlands, aquifers, and; social and economic impacts to downstream uses or users.
- Potential for multiple purposes.

Water Quality

- Consider effects on erosion and the movement of sediment, pathogens, and soluble and sediment-attached substances that are carried by runoff.
- Effects on the visual quality of onsite and downstream water resources.
- Short-term and construction-related effects of this practice on the quality of downstream water courses.
- Effects of water level control on the temperatures of downstream water to prevent undesired effects on aquatic and wildlife communities.
- Effects on wetlands and water-related wildlife habitats.
- Effects of water levels on soil nutrient processes such as plant nitrogen use or denitrification.
- Effects of soil water level control on the salinity of soils, soil water, or downstream water.
- Potential for earth moving to uncover or redistribute toxic or undesirable materials such as saline soils.

PLANS AND SPECIFICATIONS

Plans and specification for installing ponds shall be in keeping with this standard and shall describe the requirements for applying the practice to achieve its intended purpose.

Drawings and construction specifications shall be provided to the landowner or his/her representative with sufficient copies for the contractor. Special construction specifications shall be prepared for the complex sites. The national guide specification and NRCS Handbooks shall be utilized in preparing these specifications. Missouri Standard Drawings and Construction Specifications 378-A and 378-B, or equivalent as applicable, will be used for all other sites.

OPERATION AND MAINTENANCE

The following University of Missouri Agricultural Guide provides information on operating and maintaining structures with embankment dams:

1548 "Maintaining Small Dams"

Table 1 -- Maximum allowable earthfill cover over Schedule SDR PVC pipe for earth dams[1, 4, 5]

Schedule for SDR (Standard Dimension Ratio)[2]	**Maximum depth of fill over pipe**[3,5] (feet)
SDR26	14
SDR21	21
SDR17	32 [4/]

Table 1a -- Maximum acceptable earthfill cover (feet) over various other PVC Pipe Types [4, 5, 6]

Type	Size (Inside Diameter)				
	4”	6”	8”	10”	12”
AWWA C900					
100 psi	15	15	15	15	15
150 psi	27 [4/]	27 [4/]	27 [4/]	27 [4/]	27 [4/]
200 psi	35 [4/]	35 [4/]	35 [4/]	35 [4/]	35 [4/]
ASTM D1785					
Schedule 40	25 [4/]	17	13	11	10
Schedule 80	35 [4/]	35 [4/]	30 [4/]	27 [4/]	25 [4/]
Schedule 120	35 [4/]	35 [4/]	35 [4/]	35 [4/]	35 [4/]

1 Polyvinyl chloride pipe, PVC 1120 or PVC 1220, conforming to ASTM D1785, ASTM D2241 or equivalent.

2 SDR = outside diameter (inches) ➎ wall thickness (inches)

3 Fill depths are based on 7 1/2% pipe deflection in accordance with Technical Release 77 - Design and Installation of Flexible Conduits - Plastic Pipe.

4 PVC pipe is not permitted in dams with total fill height greater than 20 feet.

5 Backfill around pipe shall be carefully placed and well tamped with a density equal to or greater than 85% of Standard Proctor.

6 Polyvinyl chloride pipe, PVC 1120 or PVC 1220 conforming to ASTM D1785, AWWA C900, or equivalent.

Table 2 -- Minimum gages or thickness for corrugated metal pipe (2-2/3 inches x 1/2 inches corrugations)

Fill Over Pipe (feet)	Steel Minimum Gauge						Aluminum[1] Minimum Thickness (inches)			
	Pipe Diameter (inches)						Pipe Diameter (inches)			
	21 and less	24	30	36	42	48	21 and less	24	30	36
1-14.9	16	16	16	14	12	10	0.06	0.06	0.075	0.075
15-19.9	16	16	16	14	12	10	0.06	0.075	0.105	0.105
20-25	16	16	14	12	10	10	0.06	0.105	.0135	(-)[2]

[1] Riveted or helical fabrication.

[2] Not permitted.

Table 3 -- Minimum Spillway Capacities. This table gives minimum requirements for sizing principal and auxiliary spillways and for determining temporary storage volume. The minimum design storm shall be Type II, 24 hour duration of frequency shown below. **This table does not apply to pond dams having an overall height greater than 35 feet.**

Drainage Area (Acres)	Effective Height of Dam (Feet)	Storage a/ (Acre-Ft)	Condition of Vegetated Spillway b/	Principal Spillway Minimum Design Storm Frequency c/ (Years)	Auxiliary Spillway Minimum Design Storm Frequency c/ (Years)
20 or less	20 or less	Less than 50	Good	d/	10
			Fair	e/	
			Poor	1	
20 or less	Greater Than 20	Less than 50	Good	e/	25
			Fair	e/	
			Poor	2	
Greater than 20	20 or less	Less than 50	Good	1 f/	25
			Fair	2 f/	
			Poor	5	
ALL OTHERS (WITH OVERALL HEIGHT 35 FEET OR LESS)			Good	2	50
			Fair	5	
			Poor	10	

a/ Total storage below crest of auxiliary spillway or top of dam if an auxiliary spillway is not provided.

b/ Description of condition from end of constructed auxiliary spillway channel to main channel or gully downstream from the dam. Good - Uniform slope with no drops to outlet channel, good sod. Fair - Uniform slope with small drops, good sod; or uniform slope with small drops, fair vegetation, and shrubby banks. Poor - Steep slopes or raw gully banks, sparse vegetation.

c/ For drainage areas up to 600 acres, storage may be determined using approximate reservoir routing methods in the Engineering Field Handbook Supplement to Chapter 11.

d/ No principal spillway is required except that where the pond is spring fed or there are other sources of steady base flow, a trickle tube shall be installed.

e/ A trickle tube shall be installed when a principal spillway is not designed.

f/ A trickle tube may be used when drainage area is 150 acres or less and the auxiliary spillway design flow is less than:

a) 200 cfs with good vegetated spillway condition.
b) 150 cfs with fair vegetated spillway condition.

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NATURAL RESOURCES CONSERVATION SERVICE

MISSOURI CONSTRUCTION SPECIFICATION

FOR

EARTH DAMS

(378-A)

General

Construction operations shall be carried out in such a manner and sequence that erosion and air and water pollution will be minimized and held within legal limits. **A land disturbance permit from the Missouri Department of Natural Resources may be needed if the disturbed area is greater than one (1) acre in size**.

The completed job shall present a workmanlike appearance and shall conform to the line, grades, and elevations shown on the drawings or as staked in the field.

All operations shall be carried out in a safe and skillful manner. Safety and health regulations shall be observed and appropriate safety measures used.

The contractor is responsible for having all utilities located at the site according to Missouri state laws prior to beginning work.

Foundation preparation

The foundation area shall be cleared of trees, logs, stumps, roots, brush, boulders, sod, and rubbish. A minimum of 3 inches of topsoil and sod shall be stripped from foundation area. The topsoil and sod are to be stockpiled.

Existing stream channels crossing the foundation area shall be sloped 2:1 or flatter and deepened and widened as necessary to remove unconsolidated sediments, stumps, roots, and other objectionable material and to accommodate compaction equipment.

After stripping, the foundation area will be prepared to assure bonding with the fill by removing loose dry material, scarifying, disking, adjusting moisture, and compacting as necessary.

Cutoff trench

The minimum depth shown on the drawing is an estimate. Final depth of cutoff trench shall be determined by observation. Side slopes of cutoff trench shall be 1 1/2:1 or flatter, as needed to be stable. Sand, gravel, and other water conducting materials shall be removed to prevent leakage under the dam.

When rock or other hard layers are encountered, a bulldozer mounted single tooth ripper shall be used to loosen all weathered material. Stair-step rock or hard ledges will require handwork to remove all loose materials and hand backfill with clay before machine backfill is started.

In some cases, it will be necessary to thoroughly clean the bottom of rock core trenches to ensure good bond and prevent leakage.

Fill placement

The material placed in the fill shall be free of detrimental amounts of sod, roots, frozen soil, stones over 6 inches in diameter (except for rock fills), and other objectionable material. To the extent they are suitable, excavated materials are to be used as fill material. The distribution and gradation of materials shall be such that there will be no lenses, pockets, streaks, or layers of material differing substantially in texture or gradation from the surrounding material. Where it is necessary to use material of varying texture and gradation, the more plastic material shall be placed in the center and upstream portions of the fill. Foundation areas and cutoff trenches shall be kept free of standing water when fill is being placed on them.

The placing and spreading of the fill shall be started at the lowest point of the foundation

and the fill shall be brought up in approximately horizontal layers not to exceed 9 inches in thickness. Each layer shall be spread, processed, and shall be compacted by one of the following methods, as specified on the drawings:

Dozer - Complete coverage by tread or track of hauling or spreading equipment. Each lift shall not exceed 5 inches in thickness.

Roller - two passes of standard tamping type roller over the entire area to be compacted. Complete coverage by the treads of loaded hauling equipment is considered equivalent to two (2) passes of tamping roller. Each lift shall not exceed 9 inches in thickness.

The tamping-type roller shall have tampers or feet projecting not less than six (6) inches from the surface of the drum and shall have a minimum static load on each tamper of 250 pounds per square inch of tamping area. Tamping rollers with minimum static load on each tamper of 125 pounds per square inch of tamping area may be used if the number of passes is increased to four (4) or the thickness of lifts is reduced to four (4) inches. (Sheepsfoot or wedgefoot drum rollers are considered tamping rollers.)

An opening in the fill for drainage during construction is permitted. Care must be taken when the fill closure is made to assure proper compaction and bond of the fill material to the existing fill. The opening shall have a bottom width wide enough to allow equipment to work on a horizontal plane. As the drainage opening is filled, the side slopes of the existing fill shall be excavated until solid material is uncovered and good bond can be attained.

Moisture control

The minimum moisture content of the fill material and foundation shall be such that, when kneaded in the hand, the fill material will form a ball which does not readily separate. The maximum moisture content is when conditions are too wet for efficient use of the hauling and compaction equipment.

Borrow areas

All borrow areas outside the pool area shall be graded and left so they are well drained, protected from erosion, and may be seeded. Borrow areas inside the pool area shall have side slopes of 2:1 or flatter.

Placement of topsoil

Available topsoil should be placed on the auxiliary spillway, the downstream slope, top, exposed surface of the upstream slope of the dam, and any other disturbed areas.

Vegetation

Refer to JS-AGRON-25 for seeding and mulching recommendations or equivalent.

Additional Details: _____

NATURAL RESOURCES CONSERVATION SERVICE

MISSOURI CONSTRUCTION SPECIFICATION

FOR

PIPE SPILLWAY

(378-B)

Materials

Materials and fabrication shall be as specified on the drawings.

Corrugated metal pipe shall conform to the requirements of ASTM A760, A762, A885, B745, or B790 as appropriate. Plastic pipes through a dam shall be polyvinyl chloride pipe, PVC 1120 or 1220 conforming to ASTM D1785, ASTM D2241, or ANSI/AWWA C900. The SDR PVC plastic sewer pipe shall conform to ASTM D3034. Ductile iron pipe shall conform to ANSI/AWWA C151/A21.51 or ASTM A674. Welded steel pipe shall meet tolerance requirements of ASTM A53 or equivalent specifications. Welded steel pipe shall be new, new reject, or high quality used pipe. Anti-seep collars shall be of materials compatible with the pipe.

Installation

The pipe conduit shall be placed on a firm foundation to the lines and grades shown on the drawings. Installation shall be conducted in a skillful and workmanlike manner.

Anti-seep collars are to be installed at locations shown on the drawings with watertight connections. When the bottom half is placed in a trench, special backfill and compaction will be required to prevent leakage.

Where no cradle is provided under the pipe, the foundation shall be covered with one (1) inch of loose, friable ML or CL soil material (Unified Soil Classification System) immediately prior to placing the pipe. This material should be saturated before additional backfill is placed.

Selected backfill of friable ML or CL material shall be placed around structures, pipe conduits, and anti-seep collars at approximately the same rate on all sides to prevent unequal pressures. Water packing is permitted for smooth steel conduits 36 inches or less in diameter when total fill over the conduit will be ten (10) feet or less. Rubber tire, hand, or manually directed power tamper will be used on backfill around all conduits or structures where water packing is not permitted or used. Extreme caution must be exercised in backfill and compaction around structures or conduits to prevent damage, movement or deflection. Compaction on the bottom half of conduits must be firm to fill all voids and supply lateral support but not to the point where uplift pressure is exerted. Fill adjacent to concrete shall not be placed until the concrete is strong enough to support the load. Adequate moisture must be maintained in all backfill material.

The minimum moisture content of fill material and foundation shall be such that when kneaded in the hand, the fill material will form a ball which does not readily separate. The maximum moisture content is when conditions are too wet for efficient use of the hauling and compaction equipment.

Equipment shall not be operated over any structure or conduit until there is sufficient backfill to prevent damage.

Additional Details: _____

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NATURAL RESOURCES CONSERVATION SERVICE

MISSOURI CONSTRUCTION SPECIFICATION

FOR

WATER SUPPLY SYSTEM FOR EARTH DAMS

(378-C)

Materials

Materials and fabrication shall be as specified on the drawings and as recommended by the manufacturer of the tank. The inside diameter of the pipe shall be as shown on drawings. All plumbing components shall be compatible with the tank and pipe used.

Plastic pipe 2 inches or less in diameter meeting ASTM specifications D-1785, D-2239, D-2241 or AWWA C-901 may be used. Plastic pipe over 2 inches in diameter shall be Polyvinyl Chloride (PVC) 1120 or 1220 conforming to ASTM D-1785 or D-2241. The ASTM or AWWA designation shall be stamped on the pipe. Steel pipe shall meet ASTM specification A-53 or equivalent. Other pipe meeting MO-NRCS Pipeline Standard 516 is acceptable.

Tanks shall be durable enough to withstand forces exerted by the water, soil, and livestock and shall have a minimum design life of 10 years. Crushed rock or gravel shall be composed of hard durable rock. Poured concrete for pad or tank shall conform to Construction Specification 750, Reinforced Concrete.

Pipe installation

The pipe trench within the dam or its foundation shall be excavated with side slopes of 1.5:1 or flatter. The pipe shall be placed on a firm foundation to the lines and grades shown on the drawings. All parts of the water system shall be installed and connected according to the manufacturer's recommendations. All joints shall be watertight.

Backfill for plastic pipe shall be free of rocks and other sharp-edged materials. Backfill material shall have adequate moisture for compaction. Compaction may be achieved by hand, rubber tire, or manually directed power tampers. Deformation or displacement of pipe must not occur during backfilling. Plastic pipe may be filled with water and capped to prevent collapsing. Equipment shall not be operated over the pipe until there is sufficient backfill to prevent damage.

The outlet pipe should be buried below frost line or otherwise protected from freezing.

Testing

Before backfilling, the pipe shall be filled with water and tested at design working head or a minimum head of 10 feet whichever is greater. All leaks shall be repaired and the test repeated before backfilling.

Pad and tank installation

The pad and the area surrounding the tank should be graded to allow surface water to drain away from the tank. Tanks shall be located away from dam or critical erosion areas whenever possible.

Refer to the drawings and Missouri Construction Specification Water Facility (614) for pad and tank requirements.

Additional Details: _____

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